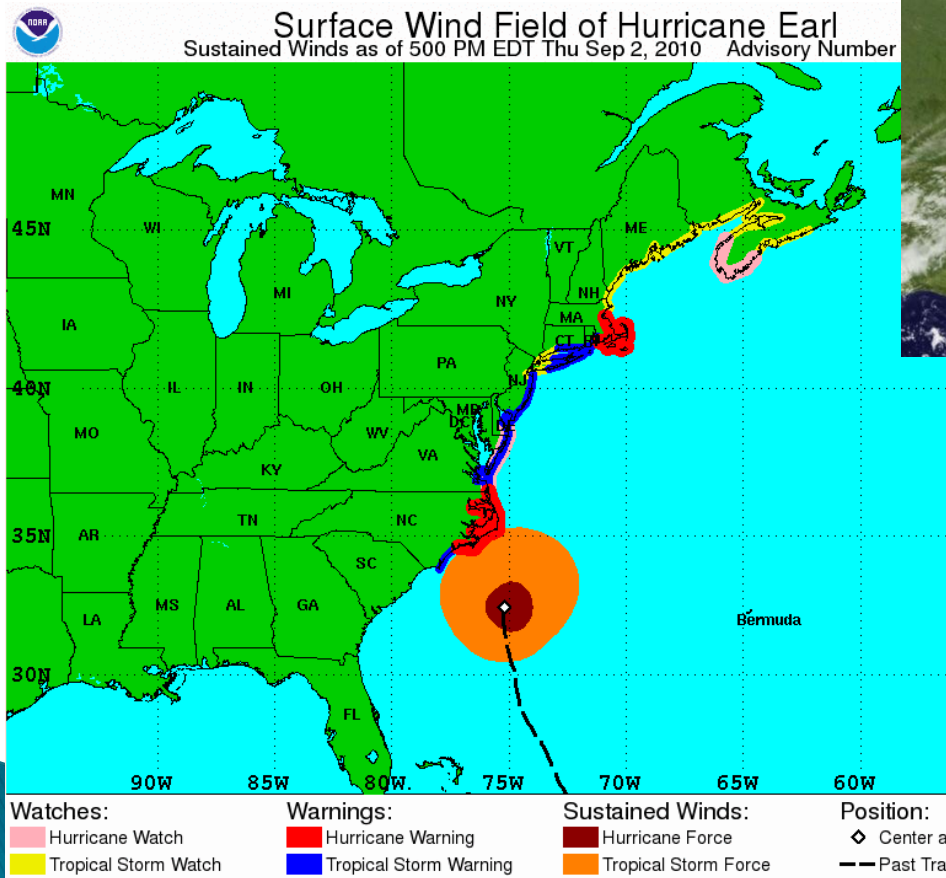


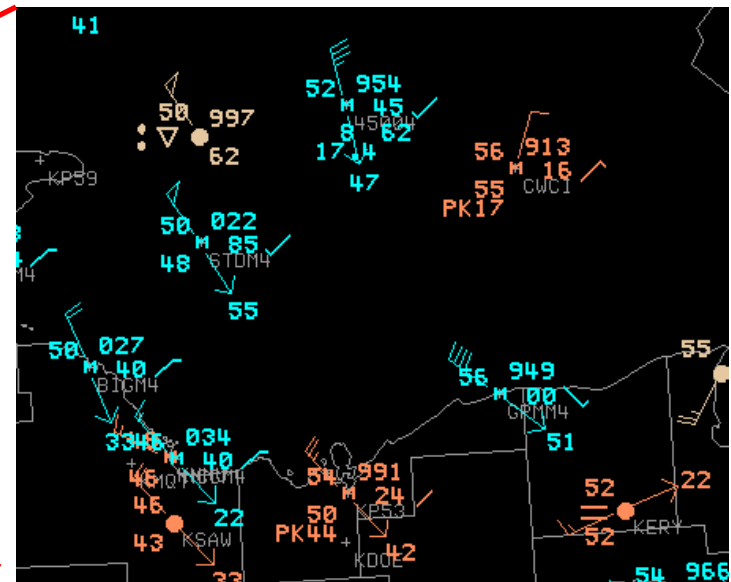
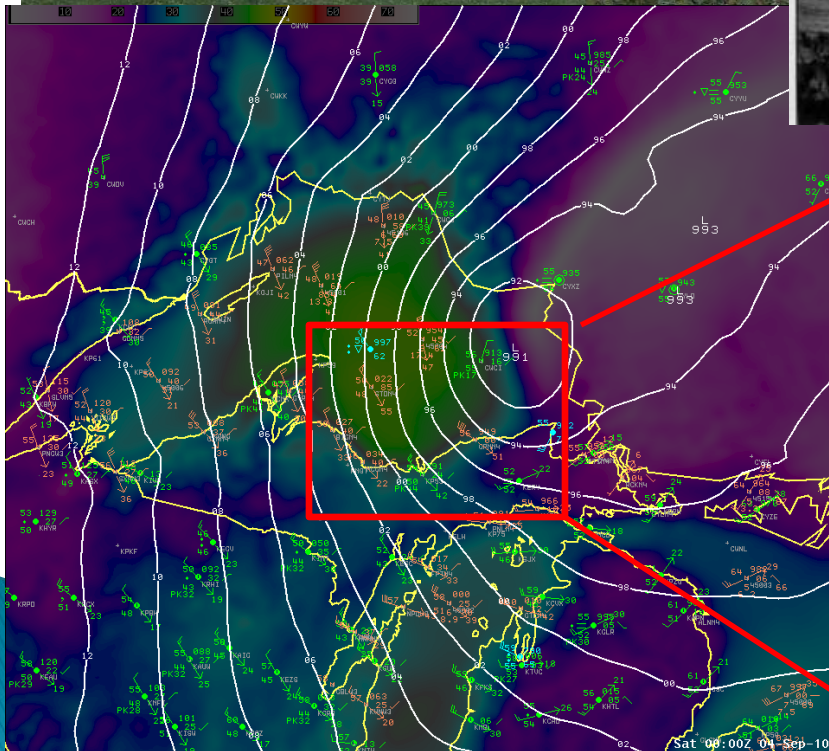
# The Lake Superior Wind Storm of 03 September 2010

Mike Dutter  
Science and Operations Officer  
NOAA/NWS Marquette, MI

# What was all of the talk on September 3<sup>rd</sup>?



# What else was going on September 3<sup>rd</sup> ??

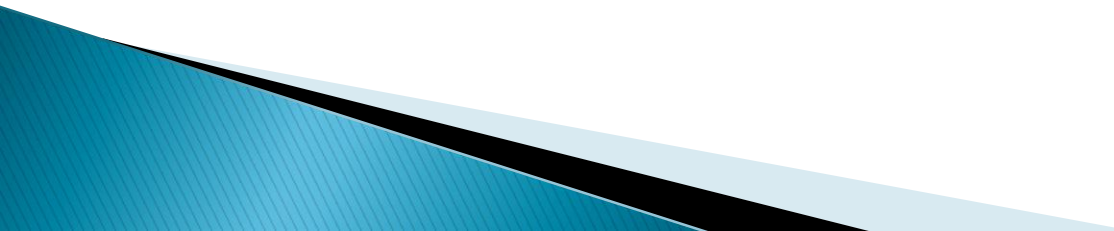




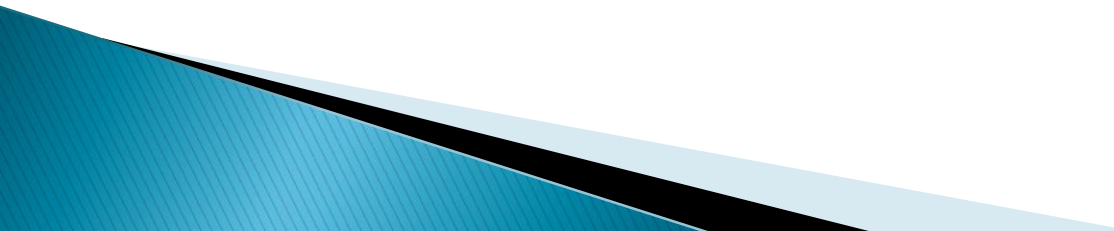
# We had our own little tropical storm of sorts...

- ▶ Peak Wind reported by any Buoy/CMAN on Lake Superior Sept 3/4...
  - Stannard Rock – 66 knots
- ▶ Numerous reports of 40–60 knot winds across the eastern half of Lake Superior
- ▶ One report by the Indiana Harbor – Peak instantaneous winds of 144 mph!!!

# Why was this storm so different from other Autumn storms

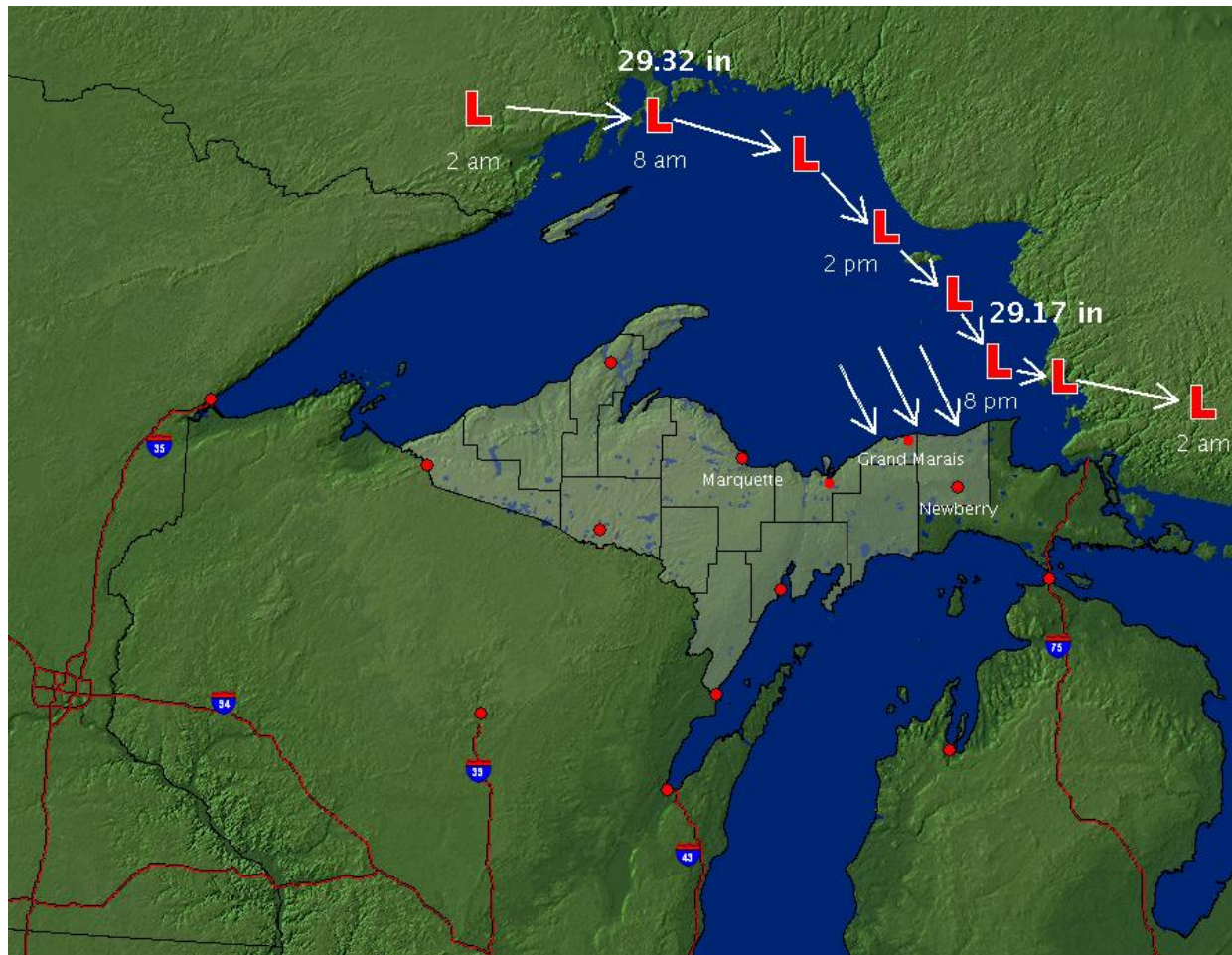
- ▶ Even for Lake Superior, this storm was very early in the season
    - Most likely the strongest storm this early in the season.
  - ▶ Arguably the strongest widespread wind across the lake since the Nov 10, 1998 storm.
  - ▶ Many September wind records on the lake were broken.
    - Even some all time records were broken
  - ▶ Most ships were riding out the storm in harbor, however there was one lone ship out there riding out the storm in the middle of the lake.
- 

# Outline

- ▶ Overview of the Storm
    - Storm Track
    - Peak Wind and Storm Reports
  - ▶ WFO Marquette Forecast and DSS activities
  - ▶ Best Practices and Recommendations
- 

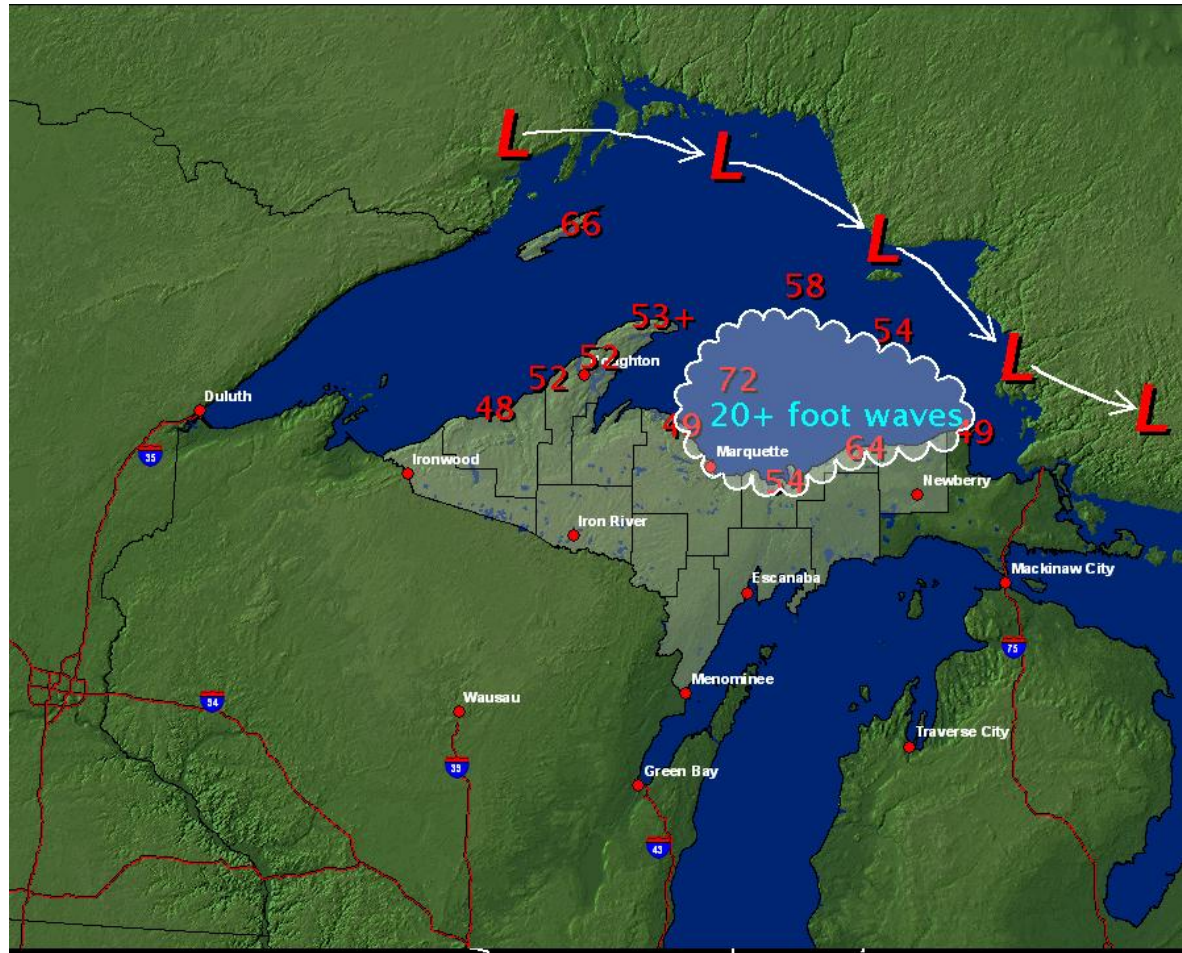
## » Storm Overview

# “Best Fit” Low Track





# Peak Wind Gusts (MPH)



# Aren't these type of strong winds and high waves normal for Lake Superior?

- ▶ In November, yes, but in September (especially early September), no!
- ▶ Buoy/CMAN September records broken (or nearly broken)...

|                                | Stannard Rock(STD M4) |                 | Eastern Buoy (45005) |                   |
|--------------------------------|-----------------------|-----------------|----------------------|-------------------|
| Record Type                    | Max on 9/3/10         | Old Record (kt) | Max on 9/3/10        | Old Record (kt)   |
| Sustained Wind Speed           | 58.1 kt               | 50.7 (9/20/03)  | 36.9 kt              | 36.2 (9/20/03)    |
| Peak Wind Gusts at Observation | 62.0 kt               | 56.8 (9/28/92)  | 46.7 kt              | 43.2 (9/28/92)    |
| Peak Wind over Previous Hour   | 63.0 kt               | 62.2 (9/22/01)  | 50.5 kt              | 46.9 (9/20/03)    |
| Wave Height                    | --                    | --              | 17.4 ft              | 17.7 ft (9/20/03) |

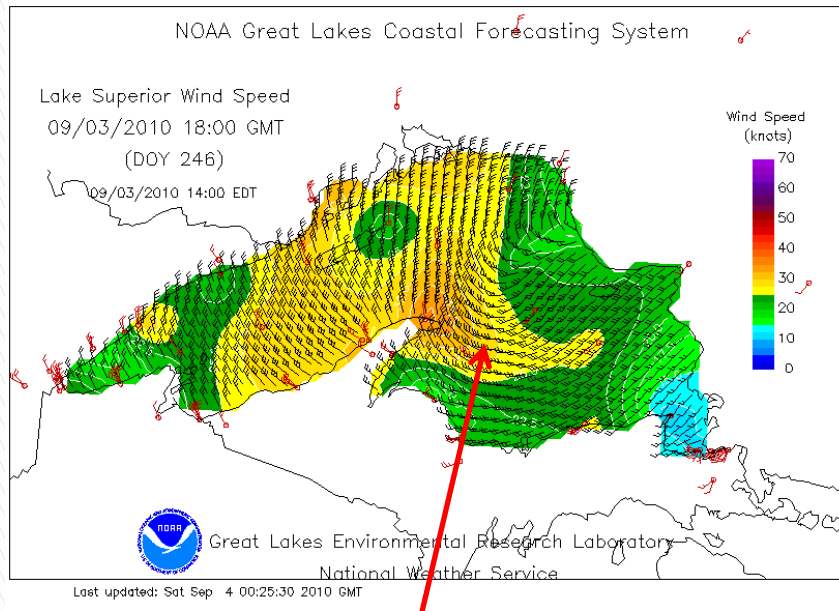


– Broke all time record Peak Wind Record ( 6/1997)



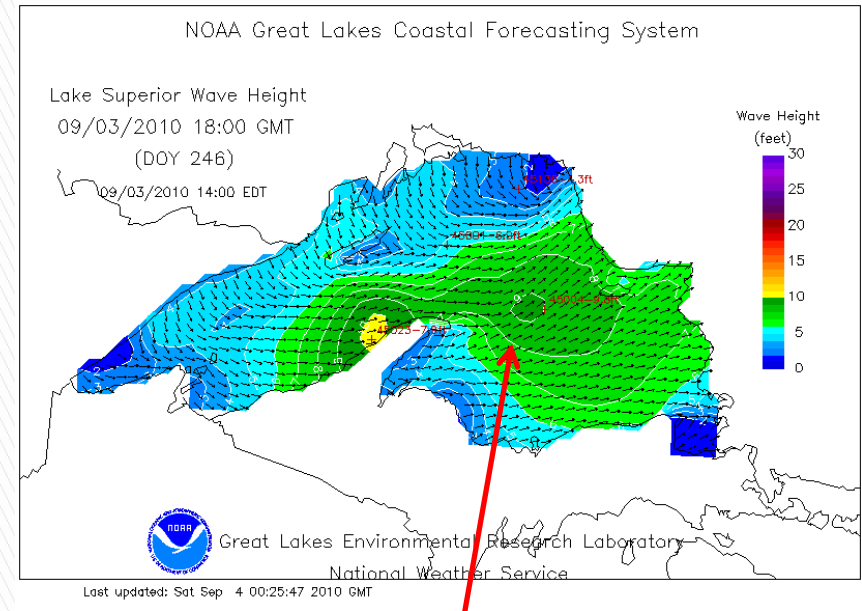
– Waves rose 12 feet in 2 hours!

# NOAA/GLERL Analysis 03/18z– 04/12z



Storm Force Winds

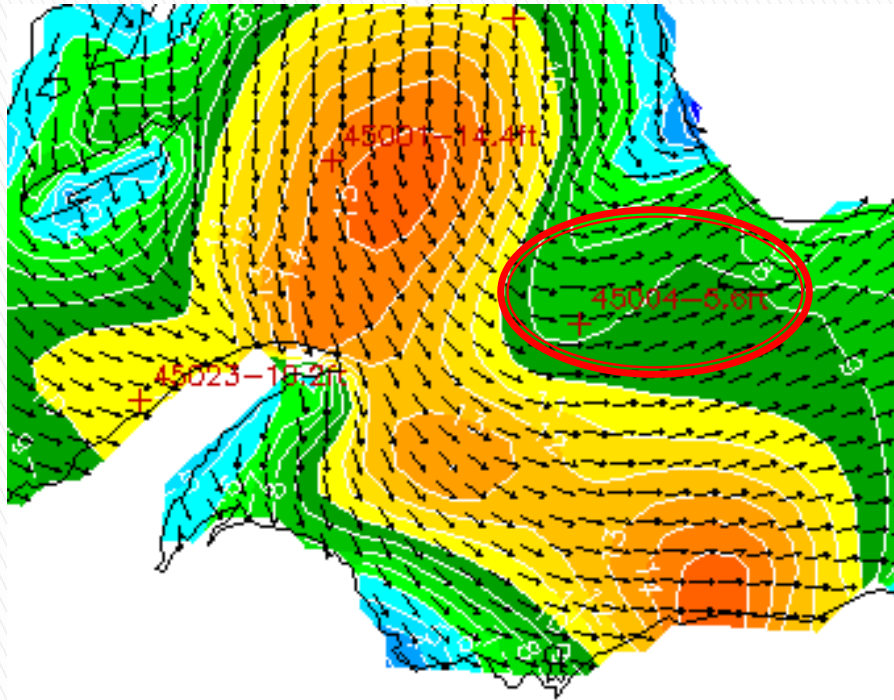
Wind



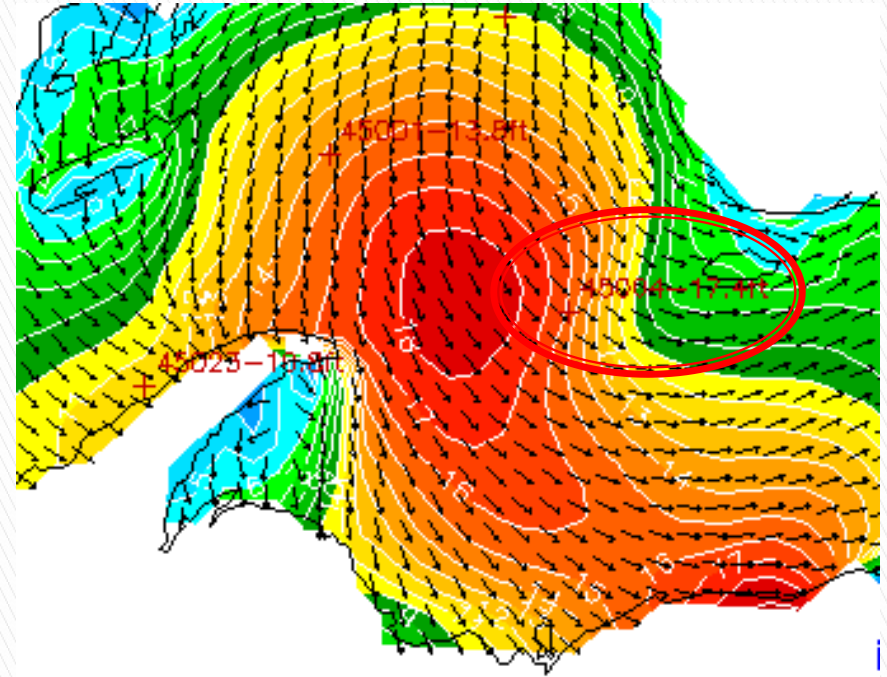
20 ft wave height

Waves

# GLERL Wave Analysis/Observations



03/22z - Waves 5.6 ft



04/00z Waves 17.4 ft



# One ship was out there...

- ▶ Indiana Harbor was in the middle of the storm just west/north of Stannard Rock...
- ▶ Damage to equipment and deck rails due to:
  - Sustained Winds of 50+kt for 4 hours (with instant winds of 100 mph)

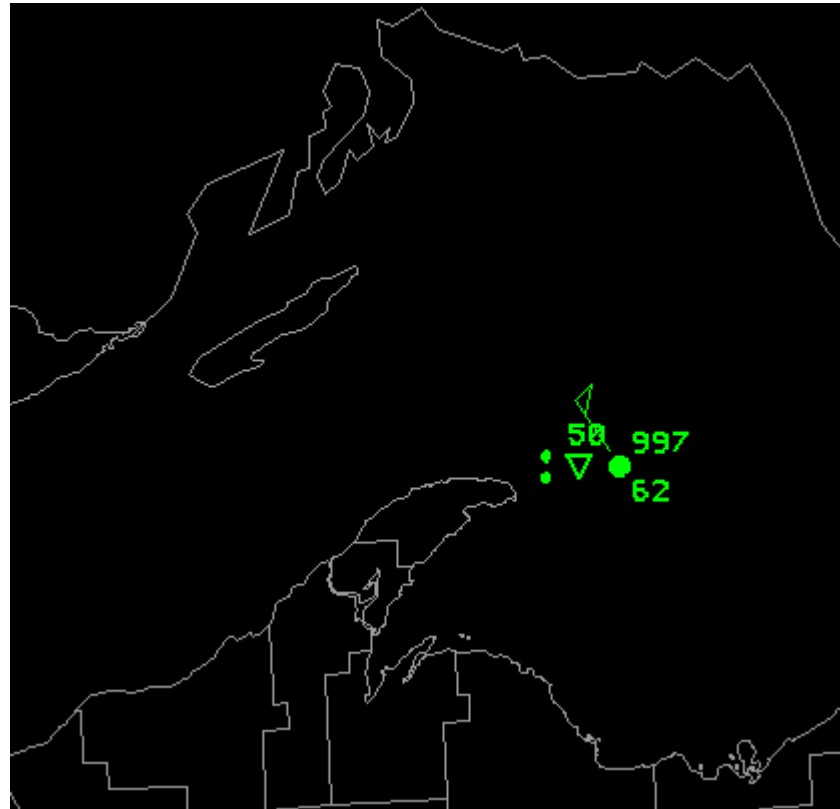


Frequent waves of 25–30 feet reported

- Blue water reported on deck

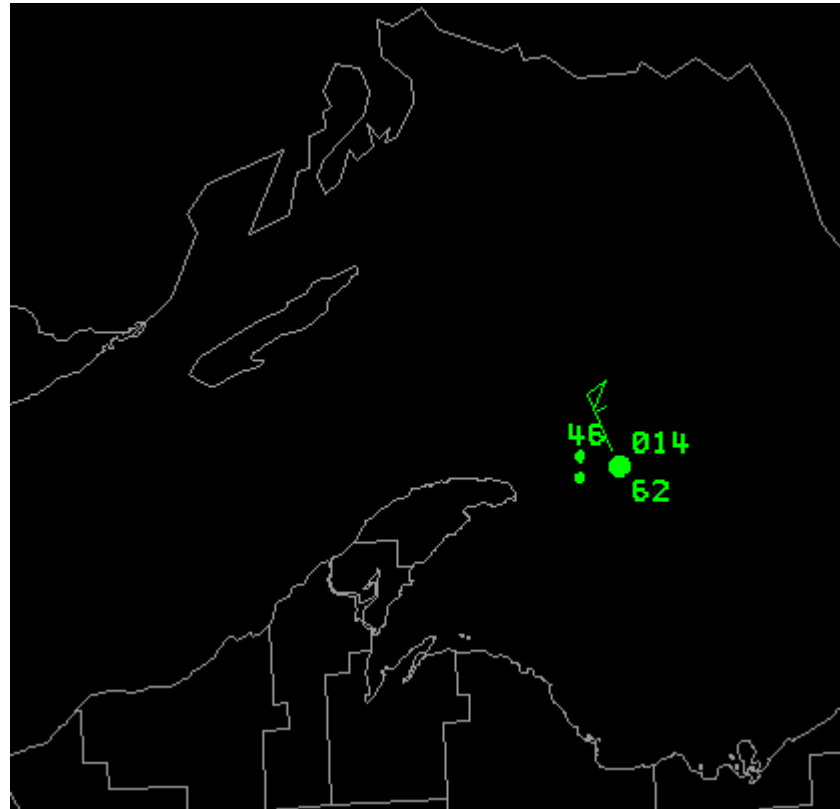


# Indiana Harbor Observations



► 00z

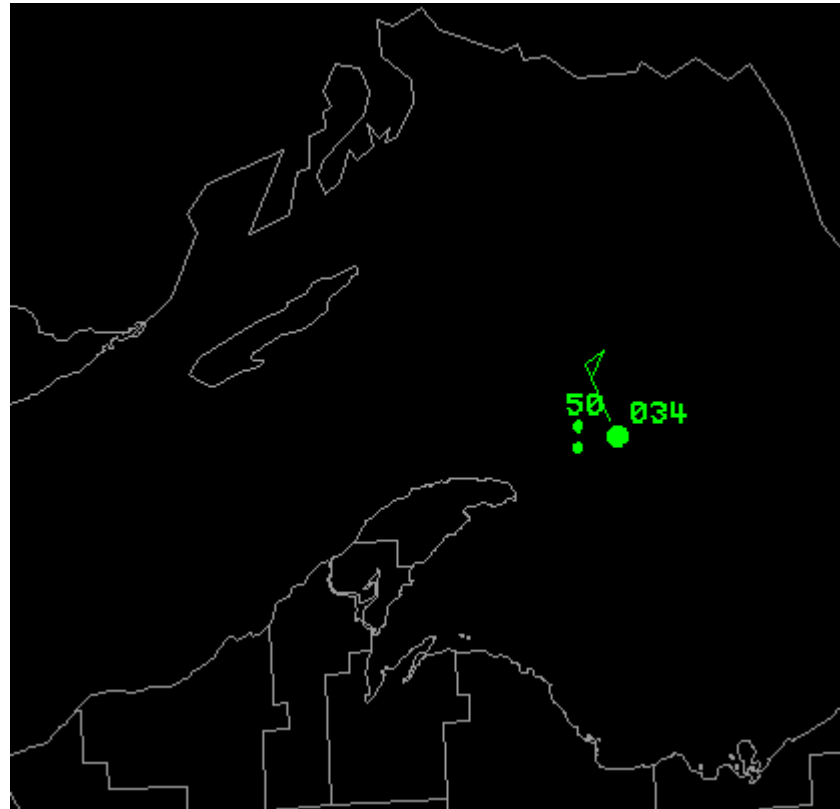
# Indiana Harbor Observations



► 01z

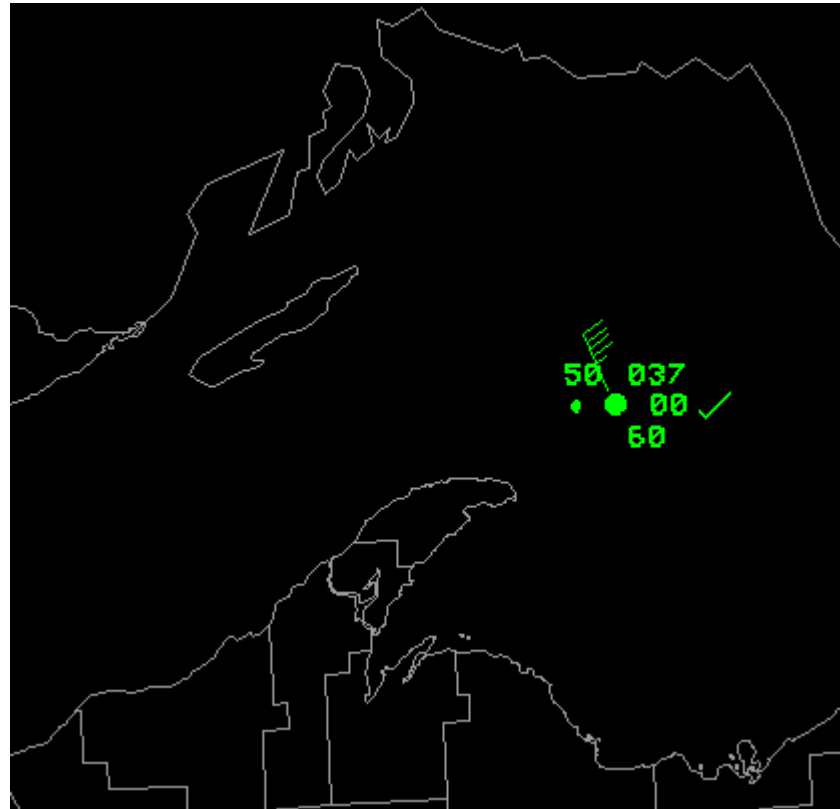


# Indiana Harbor Observations



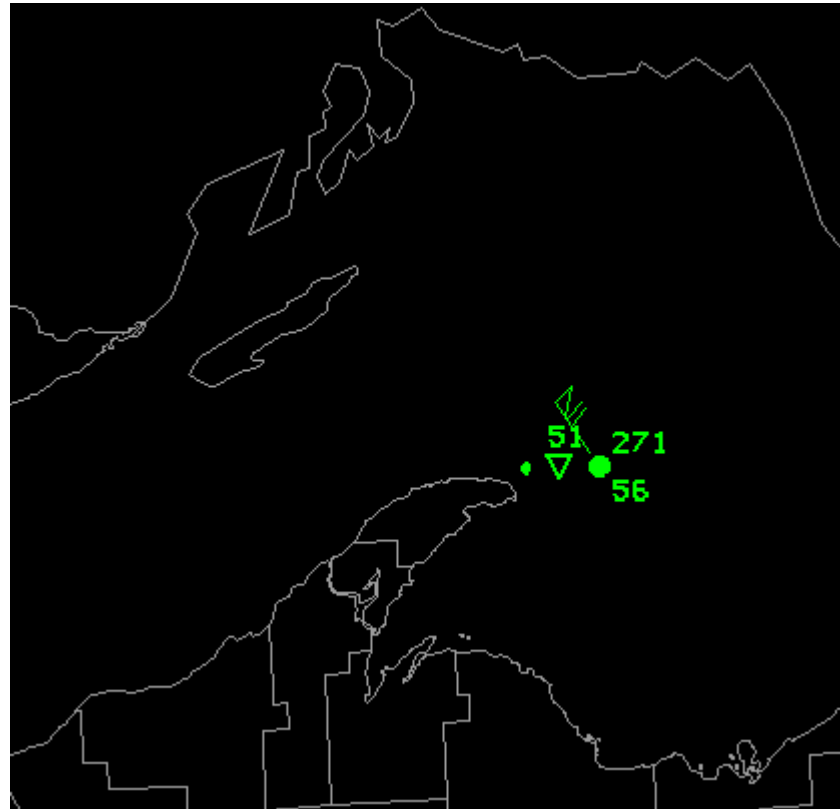
► 02z

# Indiana Harbor Observations



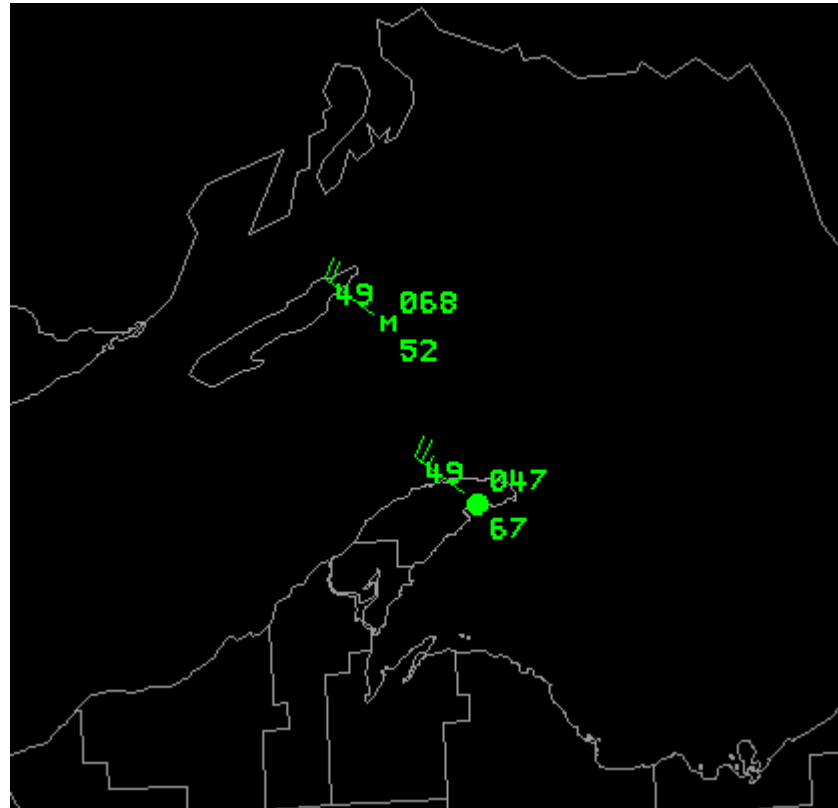
▶ 03z

# Indiana Harbor Observations



► 05z

# Indiana Harbor Observations

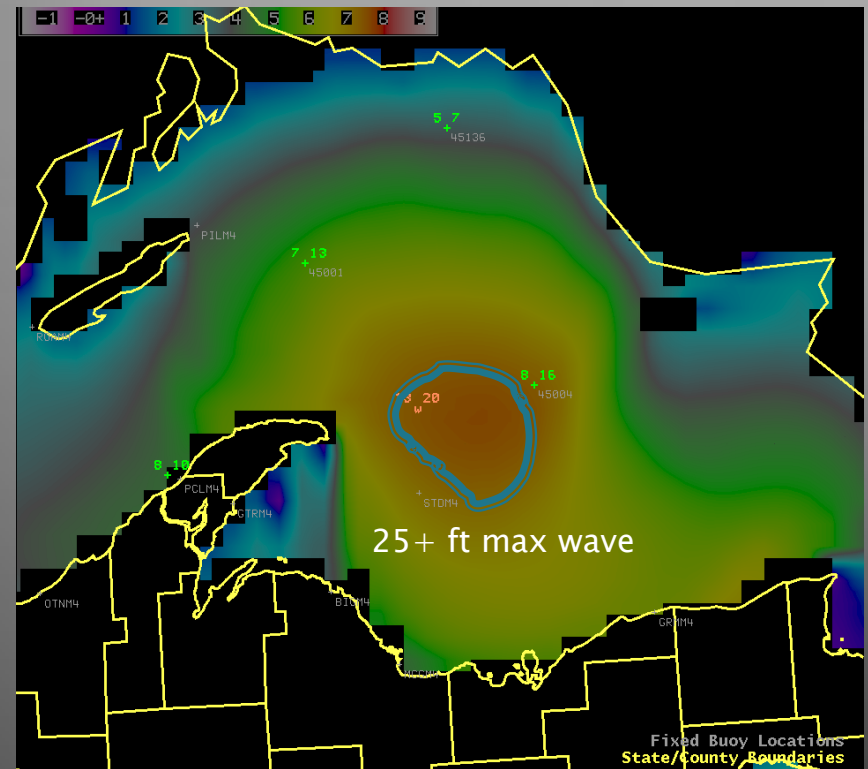


► 09z



Why 25–30 foot waves? The analysis showed only 20 foot waves (which was forecast).

- ▶ The ship was likely seeing the “max” wave (avg of highest 10%) based on the Rayleigh Distribution
  - $H_{max} = 1.272 * H_s$
- ▶ Why don't we include more of this information in our forecasts?



## 04/01z Max Wave Calculation

# Example MWW from LOT

URGENT - MARINE WEATHER MESSAGE  
NATIONAL WEATHER SERVICE CHICAGO IL  
948 AM CDT SUN OCT 3 2010

LMZ740-741-032300-  
/O.CON.KLOT.SC.Y.0071.000000T0000Z-101004T0300Z/  
WINTHROP HARBOR TO WILMETTE HARBOR-  
WILMETTE HARBOR TO NORTHERLY ISLAND-  
948 AM CDT SUN OCT 3 2010

...SMALL CRAFT ADVISORY REMAINS IN EFFECT UNTIL 10 PM CDT THIS  
EVENING...

\* EXPECT HAZARDOUS CONDITIONS FOR SMALL CRAFT UNTIL 10 PM CDT  
THIS EVENING.

\* DURING THE SMALL CRAFT ADVISORY... THE STRONGEST WINDS WILL BE  
UP TO 25 KT FROM THE NORTH. THE HIGHEST SIGNIFICANT WAVES  
WILL BE UP TO 9 FT. THERE WILL BE OCCASIONAL WAVES UP TO 13 FT.

REFER TO THE LATEST MARINE FORECASTS FOR MORE DETAILED  
INFORMATION.

# Lake Huron Open Lake Forecast from DTX

OPEN LAKE FORECAST FOR LAKE HURON...UPDATED  
NATIONAL WEATHER SERVICE DETROIT/PONTIAC MI  
1233 PM EDT FRI OCT 15 2010

LAKE HURON FORECAST BEYOND FIVE NAUTICAL MILES FROM SHORE

.SYNOPSIS...A LOW PRESSURE SYSTEM...29.70 INCHES...CURRENTLY OVER  
CENTRAL INDIANA WILL MOVE SOUTHEASTWARD TO THE DELMARVA PENINSULA  
TODAY. HIGH PRESSURE...AVERAGING 30.10 INCHES...WILL BUILD INTO THE  
WESTERN GREAT LAKES TODAY...THEN INTO THE CENTRAL GREAT LAKES ON  
SATURDAY. ANOTHER COLD FRONT WILL MOVE THROUGH THE CENTRAL GREAT  
LAKES SATURDAY NIGHT...AS ANOTHER HIGH PRESSURE SYSTEM BUILDS INTO  
THE GREAT LAKES SUNDAY AND MONDAY.

LHZ361-152000-

LAKE HURON FROM 5NM EAST OF MACKINAC BRIDGE TO PRESQUE ISLE LT  
BEYOND 5 NM OFF SHORE-  
1233 PM EDT FRI OCT 15 2010

.THIS AFTERNOON...NORTH WINDS 10 TO 15 KNOTS. SIGNIFICANT WAVES 1 TO  
3 FEET.

.TONIGHT...NORTHWEST WINDS 15 TO 20 KNOTS...BECOMING NORTH 10 TO 15  
KNOTS...THEN DIMINISHING TO 5 TO 10 KNOTS. SIGNIFICANT WAVES 1 TO 3  
FEET...SUBSIDING TO 2 FEET OR LESS LATE.

.SATURDAY...VARIABLE WINDS 10 KNOTS OR LESS...BECOMING SOUTHWEST 5  
TO 10 KNOTS. SIGNIFICANT WAVES 2 FEET OR LESS.

.SATURDAY NIGHT...SOUTHWEST WINDS 10 TO 20 KNOTS...BECOMING  
NORTHWEST 20 TO 25 KNOTS. SIGNIFICANT WAVES 2 FEET OR  
LESS...BUILDING TO 3 TO 5 FEET LATE. MAXIMUM WAVE HEIGHT AROUND 6  
FEET.

.SUNDAY...NORTHWEST WINDS 15 TO 20 KNOTS WITH GUSTS TO 25  
KNOTS...INCREASING TO 20 TO 25 KNOTS WITH GUSTS TO 30 KNOTS.

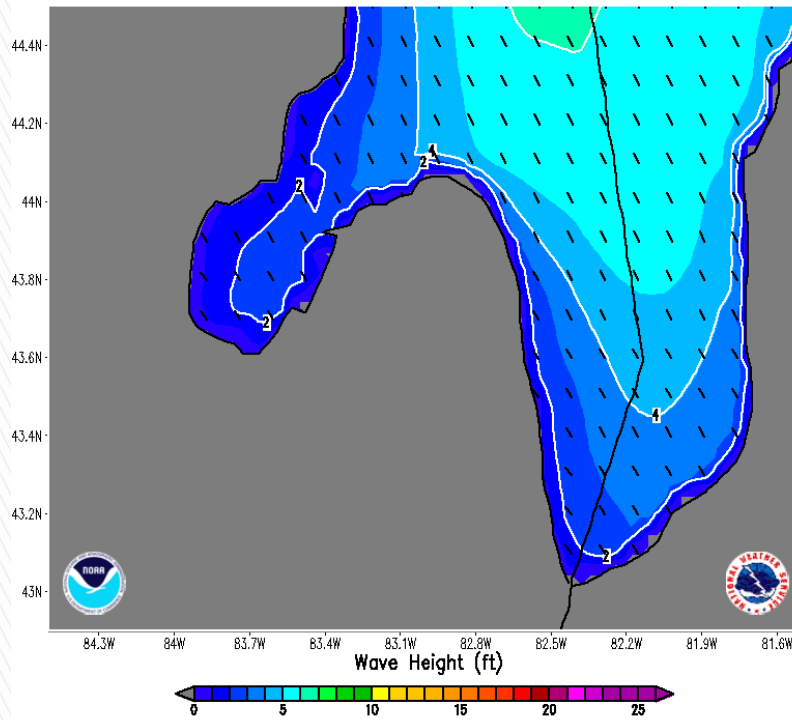
SIGNIFICANT WAVES 2 TO 4 FEET...BUILDING TO 4 TO 6 FEET DURING THE  
AFTERNOON. MAXIMUM WAVE HEIGHT AROUND 8 FEET.

.MONDAY...NORTHWEST WINDS 15 TO 20 KNOTS...DIMINISHING TO 10 TO 15  
KNOTS. A SLIGHT CHANCE OF SHOWERS. SIGNIFICANT WAVES 2 TO 4  
FEET...SUBSIDING TO 1 TO 3 FEET BY NOON.

.TUESDAY...WEST WINDS 10 TO 20 KNOTS. A CHANCE OF SHOWERS.  
SIGNIFICANT WAVES 1 TO 3 FEET...BUILDING TO 2 TO 4 FEET DURING THE  
EVENING.

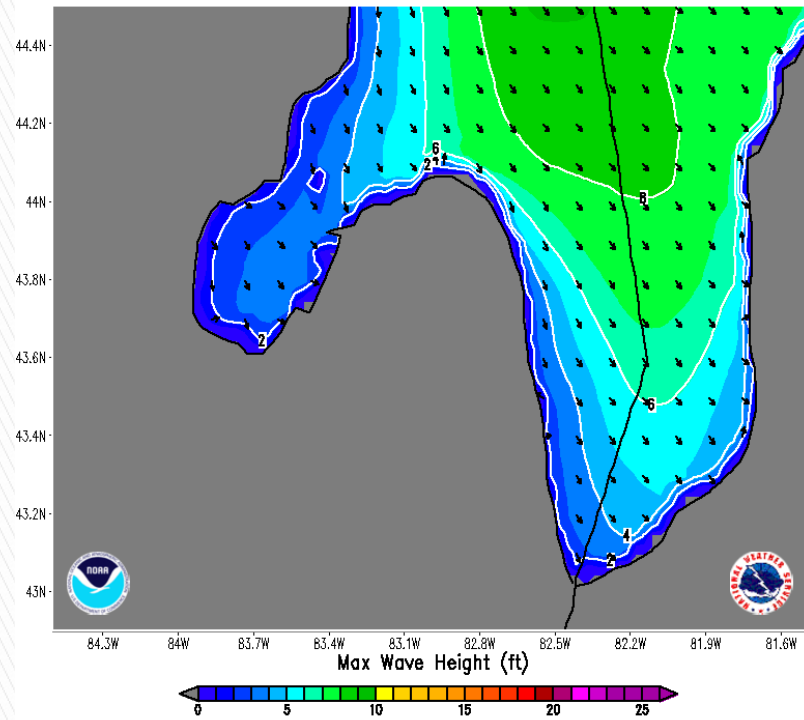
# Coast Guard DSS Portal from DTX

Wind (kt) and Wave Height (ft) Forecast  
10/07/2010 04EDT



Sig Wave Fcst

Max Wave Height (ft) and Dir Forecast  
10/07/2010 04EDT



Max Wave Fcst

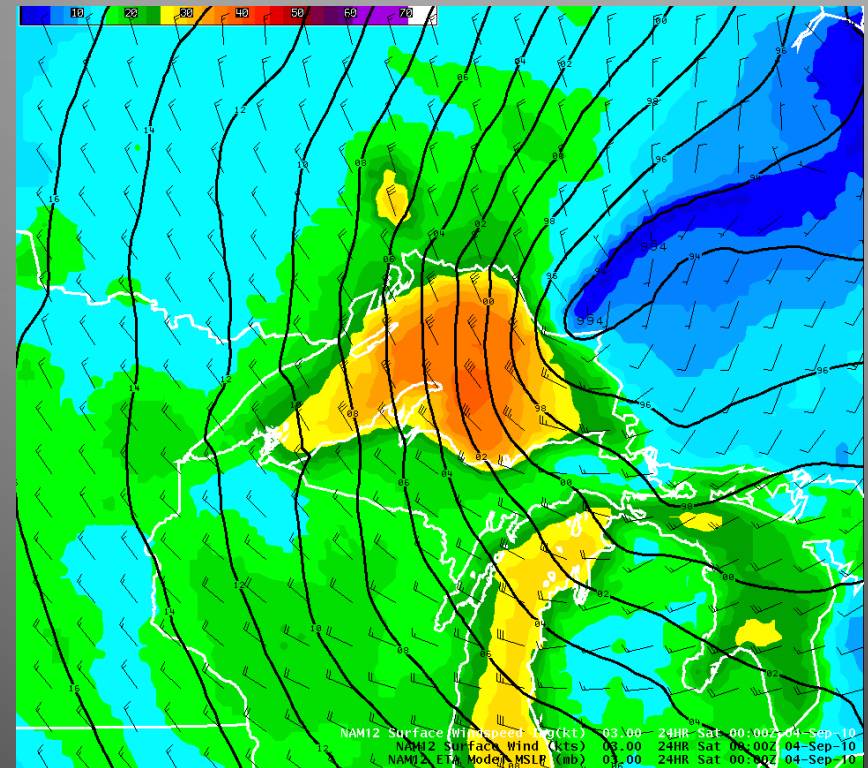


# WFO Marquette Forecasts and DSS Actions

» Including Customer Feedback

# The forecast was challenging

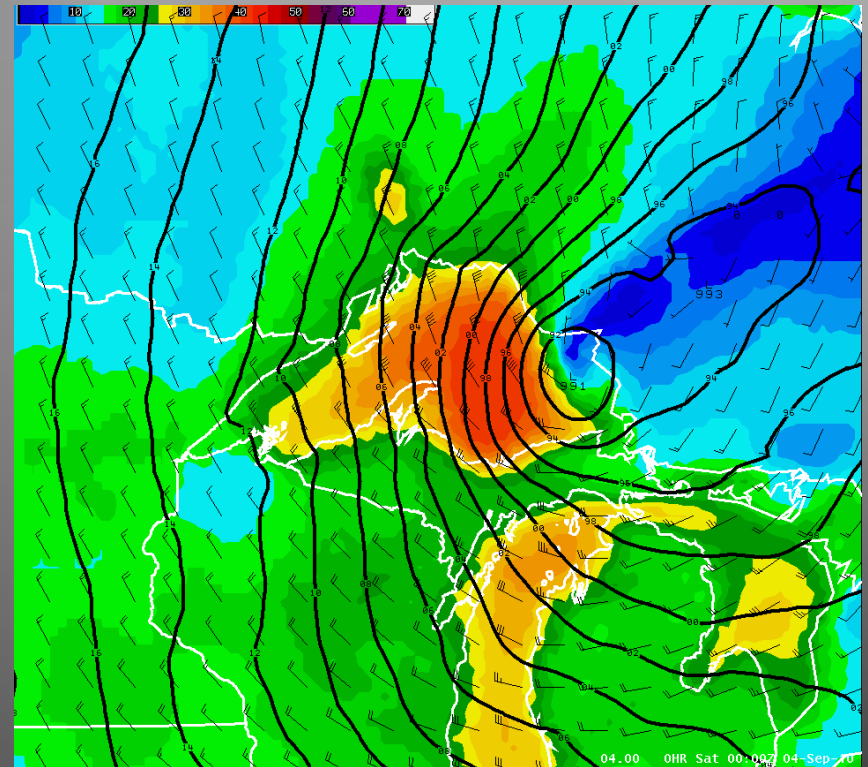
- ▶ The models suggested that the low would move east into Ontario.
  - Although the winds would be strong on the lake, storm force winds were not forecast by the models due to the weaker/further east low track.



03/00z NAM 24 hr Wind/Pressure Fcst

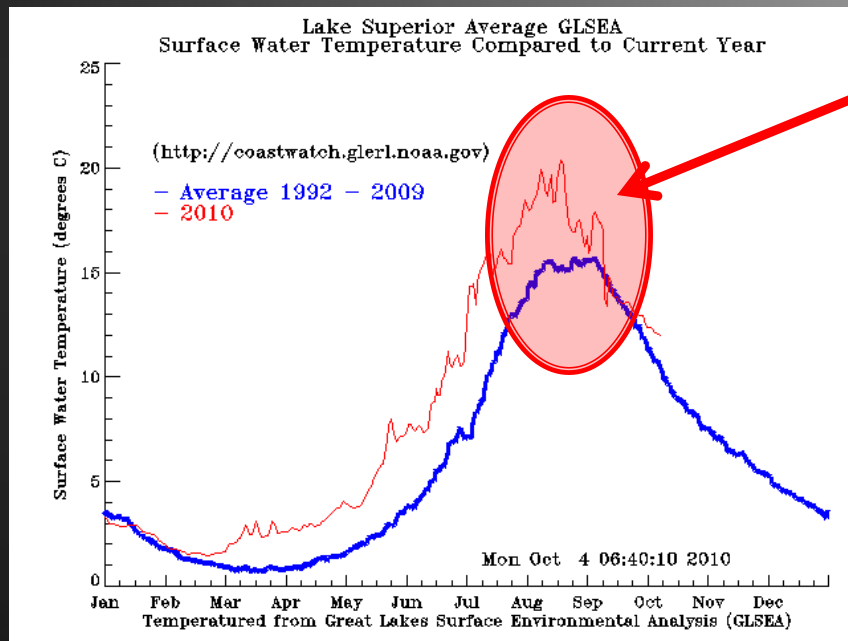
# The forecast was challenging

- ▶ The models suggested that the low would move east into Ontario.
  - Although the winds would be strong on the lake, storm force winds were not forecast by the models due to the weaker/further east low track.



04/00z NAM 00 hr Wind/Pressure Fcst

# Why did the low stay closer to the lake?



- ▶ Water temperatures on Lake Superior were the warmest since 1998 (and perhaps ever)
- ▶ The “lake aggregate” likely helped to cause a more intense low pressure system.

# What went into the forecast

- ▶ Experienced forecasters at WFO Marquette knew of the possibility of a stronger low due to the lake aggregate.
- ▶ Wind Speeds were generally increased from model guidance.
- ▶ Near Storm Force Winds (gales to 45 kt) were mentioned up to 48 hours ahead of time (Thu morning)
  - Gale watch issued at 339 pm on Wed 9/1

# WFO Marquette Forecast Details – GLF on 9/1

339 PM EDT WED SEP 1 2010

...GALE WATCH IN EFFECT FROM FRIDAY AFTERNOON THROUGH SATURDAY EVENING...

.LATE THIS AFTERNOON...NORTHWEST WINDS 10 TO 20 KNOTS. WAVES 2 TO 4 FEET.

.TONIGHT...WEST WINDS 5 TO 15 KNOTS BACKING SOUTH AFTER MIDNIGHT. WAVES SUBSIDING TO CALM TO 2 FEET.

.THURSDAY...SOUTHEAST WINDS 10 TO 20 KNOTS INCREASING TO 15 TO 25 KNOTS BY MID AFTERNOON. A CHANCE OF SHOWERS AND THUNDERSTORMS BY MID AFTERNOON. WAVES BUILDING TO 2 TO 4 FEET.

.THURSDAY NIGHT...SOUTH WINDS 15 TO 25 KNOTS VEERING SOUTHWEST AFTER MIDNIGHT. THUNDERSTORMS LIKELY THROUGH MIDNIGHT. SHOWERS LIKELY. WAVES BUILDING TO 3 TO 5 FEET...THEN SUBSIDING TO 2 TO 4 FEET.

.FRIDAY...WEST WINDS 20 TO 30 KNOTS BECOMING NORTHWEST GALES TO 40 KNOTS BY MID AFTERNOON. A CHANCE OF SHOWERS. WAVES BUILDING TO 12 TO 17 FEET.

.FRIDAY NIGHT...NORTH GALES TO 45 KNOTS BECOMING NORTHWEST GALES TO 40 KNOTS AFTER MIDNIGHT. A CHANCE OF SHOWERS. WAVES BUILDING TO 15 TO 20 FEET.



# WFO Marquette Forecast Details – GLF on the 2nd

355 AM EDT THU SEP 2 2010

...GALE WARNING IN EFFECT FROM FRIDAY AFTERNOON THROUGH LATE SATURDAY NIGHT...

.EARLY THIS MORNING...SOUTH WINDS 5 TO 15 KNOTS. WAVES CALM TO 2 FEET.

.TODAY...SOUTHEAST WINDS 10 TO 20 KNOTS INCREASING TO 15 TO 25 KNOTS BY MID AFTERNOON. SCATTERED SHOWERS AND A CHANCE OF THUNDERSTORMS BY MID AFTERNOON. WAVES BUILDING TO 3 TO 5 FEET.

.TONIGHT...SOUTHEAST WINDS 15 TO 25 KNOTS BECOMING SOUTHWEST 20 TO 30 KNOTS AFTER MIDNIGHT. SHOWERS AND A CHANCE OF THUNDERSTORMS THROUGH MIDNIGHT...THEN A CHANCE OF SHOWERS AFTER MIDNIGHT. WAVES BUILDING TO 4 TO 7 FEET.

.FRIDAY...SOUTHWEST WINDS 10 TO 20 KNOTS BECOMING WEST 15 TO 25 KNOTS BY EARLY AFTERNOON...THEN INCREASING TO GALES TO 35 KNOTS LATE IN THE AFTERNOON. SHOWERS LIKELY. WAVES SUBSIDING TO 3 TO 5 FEET...THEN BUILDING TO 6 TO 9 FEET.

.FRIDAY NIGHT...NORTH GALES TO 45 KNOTS. SHOWERS LIKELY THROUGH MIDNIGHT...THEN A CHANCE OF SHOWERS AFTER MIDNIGHT. WAVES BUILDING TO 17 TO 22 FEET...THEN SUBSIDING TO 15 TO 20 FEET.

Gale warning issued at 355 am on 9/2.

No mention of storm force winds in the forecast, however winds to 45 knots is significant

# WFO Marquette Forecast Details – GLF on the 2<sup>nd</sup> (cont)

415 PM EDT THU SEP 2 2010

...GALE WARNING IN EFFECT FROM FRIDAY AFTERNOON THROUGH SATURDAY MORNING...

.LATE THIS AFTERNOON...SOUTH WINDS 15 TO 25 KNOTS. A CHANCE OF SHOWERS AND THUNDERSTORMS. WAVES 3 TO 5 FEET.

.TONIGHT...SOUTHWEST WINDS 10 TO 20 KNOTS BECOMING WEST 15 TO 25 KNOTS AFTER MIDNIGHT. SHOWERS LIKELY AND A SLIGHT CHANCE OF THUNDERSTORMS THROUGH MIDNIGHT...THEN A CHANCE OF SHOWERS AFTER MIDNIGHT. WAVES SUBSIDING TO 1 TO 3 FEET...THEN BUILDING TO 4 TO 7 FEET.

.FRIDAY...WEST WINDS 15 TO 25 KNOTS INCREASING TO GALES TO 35 KNOTS BY MID AFTERNOON. SHOWERS LIKELY. WAVES BUILDING TO 9 TO 12 FEET.

.FRIDAY NIGHT...NORTHWEST GALES 45 KNOTS WITH STORM FORCE GUSTS UP TO 55 KNOTS. SHOWERS LIKELY. WAVES BUILDING TO 17 TO 22 FEET.

- ▶ Continued the Gale Warning at 415 pm issuance.
- ▶ Started to mention storm force gusts to 55 kt.
  - Should we issue a storm warning based on a few gusts?

# WFO Marquette Forecast Details – GLF on the 3rd

348 AM EDT FRI SEP 3 2010

...GALE WARNING IN EFFECT FROM 2 PM EDT THIS AFTERNOON THROUGH  
LATE SATURDAY NIGHT...

.EARLY THIS MORNING...WEST WINDS 15 TO 25 KNOTS. A CHANCE OF  
SHOWERS AND A SLIGHT CHANCE OF THUNDERSTORMS. WAVES 2 TO 4 FEET  
BUILDING TO 3 TO 5 FEET.

.TODAY...WEST WINDS 20 TO 30 KNOTS INCREASING TO GALES TO  
40 KNOTS BY MID AFTERNOON. SHOWERS LIKELY. WAVES BUILDING TO  
10 TO 14 FEET.

.TONIGHT...NORTH GALES TO 45 KNOTS DIMINISHING TO GALES TO 40 KNOTS  
AFTER MIDNIGHT. STORM FORCE GUSTS TO 50 KNOTS ARE POSSIBLE. SHOWERS  
LIKELY. WAVES BUILDING TO 15 TO 20 FEET.

- No major changes to the forecast at the 348 am issuance of the GLF.
- Shift change briefing at 8am suggested that we may need a storm warning, although it would be close.

# WFO Marquette Forecast Details – GLF on the 3rd

1023 AM EDT FRI SEP 3 2010

...GALE WARNING IN EFFECT FROM 2 PM EDT THIS AFTERNOON THROUGH LATE SATURDAY NIGHT...

.REST OF TODAY...WEST WINDS 20 TO 30 KNOTS BECOMING NORTHWEST GALES TO 40 KNOTS. SHOWERS LIKELY. WAVES 4 TO 7 FEET BUILDING TO 12 TO 17 FEET.

.TONIGHT...NORTH GALES TO 45 KNOTS DIMINISHING TO GALES TO 40 KNOTS. STORM FORCE GUSTS TO 50 KNOTS ARE POSSIBLE. SHOWERS LIKELY. WAVES BUILDING TO 15 TO 20 FEET.

No SR.W, but continued storm gusts

406 PM EDT FRI SEP 3 2010

...GALE WARNING IN EFFECT THROUGH LATE SATURDAY NIGHT...

.LATE THIS AFTERNOON...NORTHWEST GALES TO 40 KNOTS...WITH A FEW STORM FORCE GUSTS TO 50 KNOTS. SHOWERS. WAVES 9 TO 12 FEET BUILDING TO 15 TO 20 FEET.

.TONIGHT...NORTH GALES TO 45 KNOTS...WITH A FEW STORM FORCE GUSTS TO 50 KNOTS THIS EVENING. SHOWERS LIKELY. WAVES BUILDING TO 20 TO 25 FEET.

537 PM EDT FRI SEP 3 2010

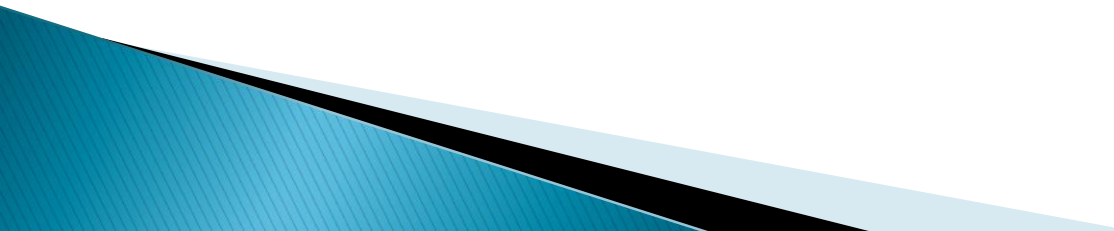
...STORM WARNING IN EFFECT UNTIL 2 AM EDT SATURDAY...  
...GALE WARNING IN EFFECT FROM 2 AM EDT SATURDAY THROUGH LATE SATURDAY NIGHT...

.LATE THIS AFTERNOON...NORTHWEST STORM FORCE WINDS TO 50 KNOTS. SHOWERS. WAVES 9 TO 12 FEET BUILDING TO 15 TO 20 FEET.

.TONIGHT...NORTH STORM FORCE WINDS TO 50 KNOTS THIS EVENING...THEN DIMINISHING TO 45 KNOT GALES OVERNIGHT. SHOWERS LIKELY. WAVES BUILDING TO 20 TO 25 FEET.

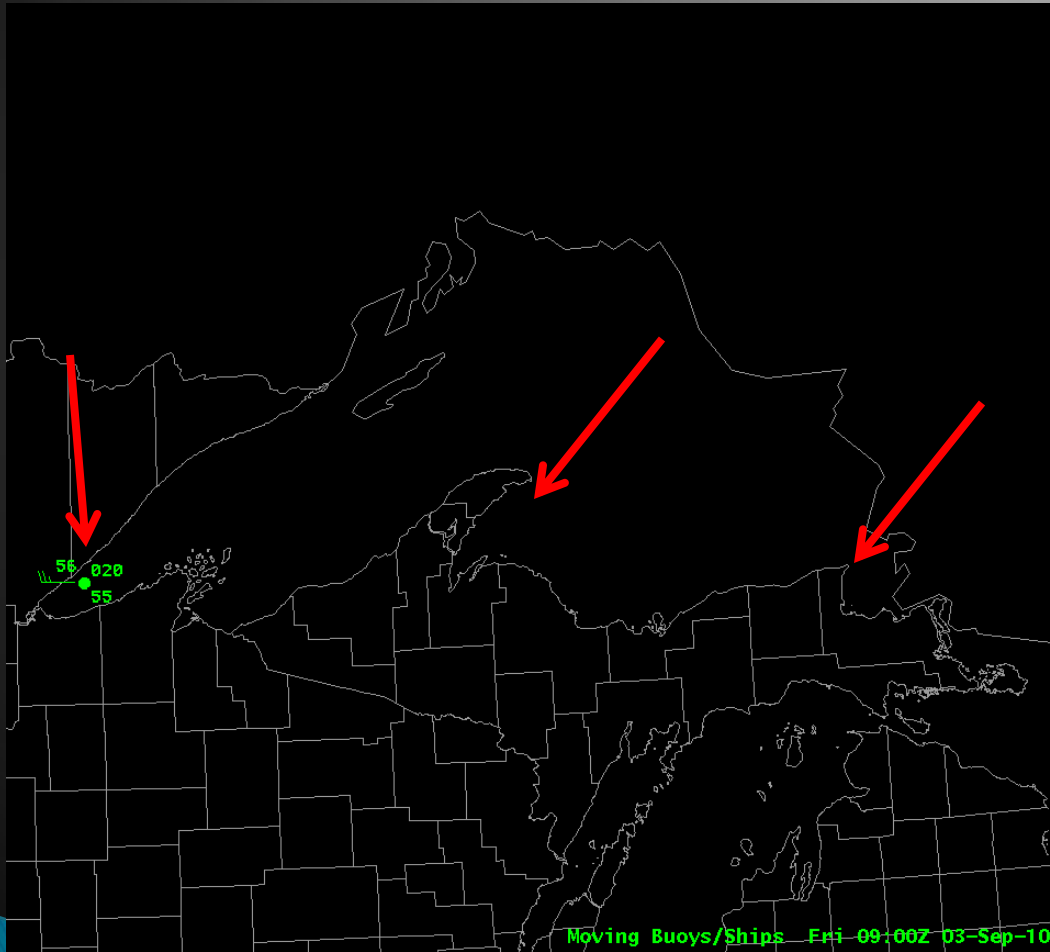
After STDM4 gusted to hurricane force...decided to go with an SR.W

# Decision Support prior to storm issuance?

1. Collaborated with Environment Canada Toronto
    - They opted to continue with Gales since winds on the northern end of the lake were weaker
  2. Called the Coast Guard Sault Ste Marie to ensure that they broadcast the Storm Warning
    - Ships heard this over their radios.
  3. Several calls from ships directly discussing the situation
- 



# What impact did this forecast have with the customers?



- ▶ Ships were aware of the bad conditions developing on the 3<sup>rd</sup>
- ▶ By early morning on the 3<sup>rd</sup>, most ships have taken refuge behind Whitefish, in DLH Harbor or behind the Keweenaw

# Extra DSS – MWS issuances at onset of storm force winds

- ▶ Added extra detail to the forecast
- ▶ Gave some timing and “real time” reports.
- ▶ Let mariners know that “bad stuff” was coming quickly.

248 PM EDT FRI SEP 3 2010

...STORM FORCE GUSTS POSSIBLE THIS AFTERNOON INTO EARLY THIS EVENING...

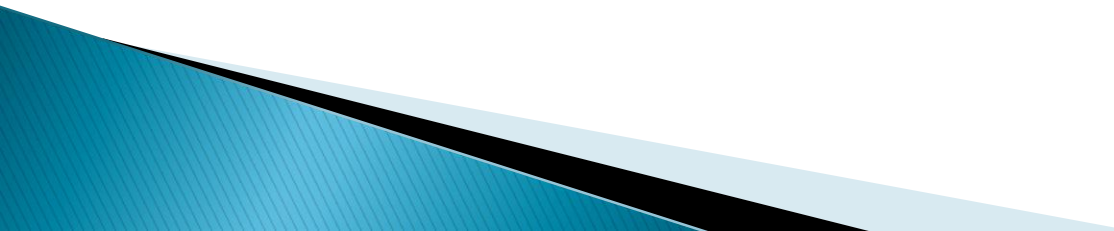
AS LOW PRESSURE OVER EASTERN LAKE SUPERIOR MOVES INTO ONTARIO...STRONG NORTH TO NORTHWEST WINDS WILL DEVELOP ACROSS CENTRAL AND EASTERN LAKE SUPERIOR. STORM FORCE WIND GUSTS TO 50 KNOTS ARE POSSIBLE THROUGH THE AFTERNOON BEFORE SUBSIDING LATER THIS EVENING. AT 224 PM EDT...THE OBSERVING SITE AT OJIBWAY ON ISLE ROYALE REPORTED A WIND GUST OF 54 KNOTS.

507 PM EDT FRI SEP 3 2010

...STORM FORCE GUSTS POSSIBLE LATE THIS AFTERNOON INTO THIS EVENING...

AS LOW PRESSURE OVER EASTERN LAKE SUPERIOR MOVES INTO ONTARIO...STRONG NORTH TO NORTHWEST WINDS WILL CONTINUE ACROSS CENTRAL AND EASTERN LAKE SUPERIOR. SUSTAINED NORTHWEST GALE FORCE WINDS TO 45 KNOTS WITH A FEW STORM FORCE WIND GUSTS TO 50 KNOTS ARE POSSIBLE LATE THIS AFTERNOON INTO THIS EVENING. THESE STORM FORCE WIND GUSTS WILL LAST SEVERAL HOURS...HOWEVER THE GALES WILL LAST THROUGH THE NIGHT AND EVEN INTO SATURDAY. AT 4 PM EDT...THE BUOY NORTH OF COPPER HARBOR...THE CANADIAN BUOY...AND STANNARD ROCK ALL REPORTED WIND GUSTS TO 47 KNOTS.

# Customer Feedback

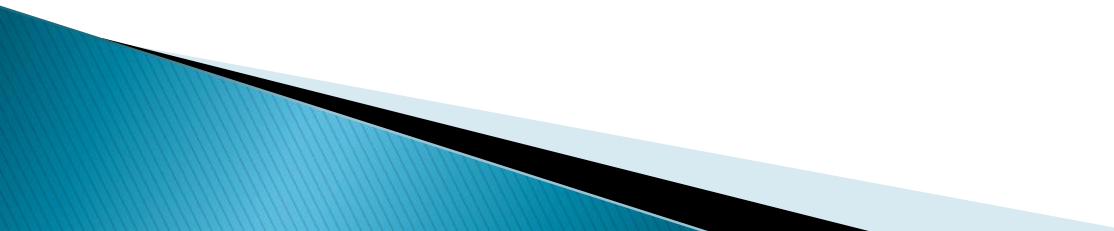
- ▶ The “lakers” were aware of the strong wind potential several days ahead of time.
  - ▶ Although we did not issue a storm warning initially, users were pleased with our forecasts and service
    - Mentioning storm force gusts in the forecast helped raise situational awareness.
    - As mentioned, many took refuge well before the event.
- 

# Best Practices



and Recommendations

# Best Practices

- ▶ Detailed MWSs allowed for additional information to be conveyed as the storm force winds commenced.
  - ▶ Direct communication with the USCG Sault Ste Marine upon Storm Warning issuance likely allowed for dangerous weather information to be more rapidly conveyed to the ships
  - ▶ Mention of storm force gusts (even without a storm warning) prompted action by the ships.
  - ▶ Direct communication with the ships before and during the height of the storm likely was important in their decision making process.
- 



# Local Recommendations

- ▶ Add further wave spectra detail in forecasts and warning information.
  - Graphical, MWW, GLF, NSH
- ▶ When upgrading to storm from a gale, do not include the lower “headline”.

537 PM EDT FRI SEP 3 2010

...STORM WARNING IN EFFECT UNTIL 2 AM EDT SATURDAY...

...GALE WARNING IN EFFECT FROM 2 AM EDT SATURDAY THROUGH LATE SATURDAY NIGHT...

.LATE THIS AFTERNOON...NORTHWEST STORM FORCE WINDS TO 50 KNOTS. SHOWERS. WAVES 9 TO 12 FEET BUILDING TO 15 TO 20 FEET.

.TONIGHT...NORTH STORM FORCE WINDS TO 50 KNOTS THIS EVENING...THEN DIMINISHING TO 45 KNOT GALES OVERNIGHT. SHOWERS LIKELY. WAVES BUILDING TO 20 TO 25 FEET.

- ▶ Even when a storm warning is issued, issue frequent updates to the MWW or even issue MWSs to highlight the threats.

# Thank You!

» michael.dutter@noaa.gov